03P07186

82

(12) UK Patent Application (19) GB (11) 2 068 589 A

(21) Application No 8103393
(22) Date of filing 4 Feb 1981
(30) Priority data
(31) 80/03758
(32) 5 Feb 1980
(33) United Kingdom (GB)
(43) Application published 12 Aug 1981
(51) INT CL³ G05B 23/02
(52) Domestic classification G3N 381 382 385 390 404 B
(56) Documents cited
GB 2042420A
GB 2037012A
GB 2001454A
GB 1522185
(58) Field of search G3N

(71) Applicant
Turnright Controls Limited,
Walton Road, Farlington,
Portsmouth, PO6 1SX
(72) Inventors
Arthur Alexander Collie,
Benjamin Peter Russell
(74) Agent
Abel & Imray,
Northumberland House,
303—306 High Holborn,
London, WC1V 7LH

(54) Improvements in and Relating to Process Controllers and Programme-controlled Machines

(57) A process controller, suitable e.g. for programme controlled washing machine 1—4, performs a sequence of operations in accordance with user commands provided by user controls. It enables a user to check components of the machine by means of the user controls and microprocessor 9.

The controller provides a test mode in which each user control becomes dedicated to a particular component which can then be selectively energised by means of its dedicated control so as to assess its operational state.

The process controller is arranged, during operation, to perform periodic checks on signals provided by sensors and to assess whether or not each signal is within specified limits at a specified time. Failure of a periodic check results in the display of a code which identifies the sensor involved in the check.

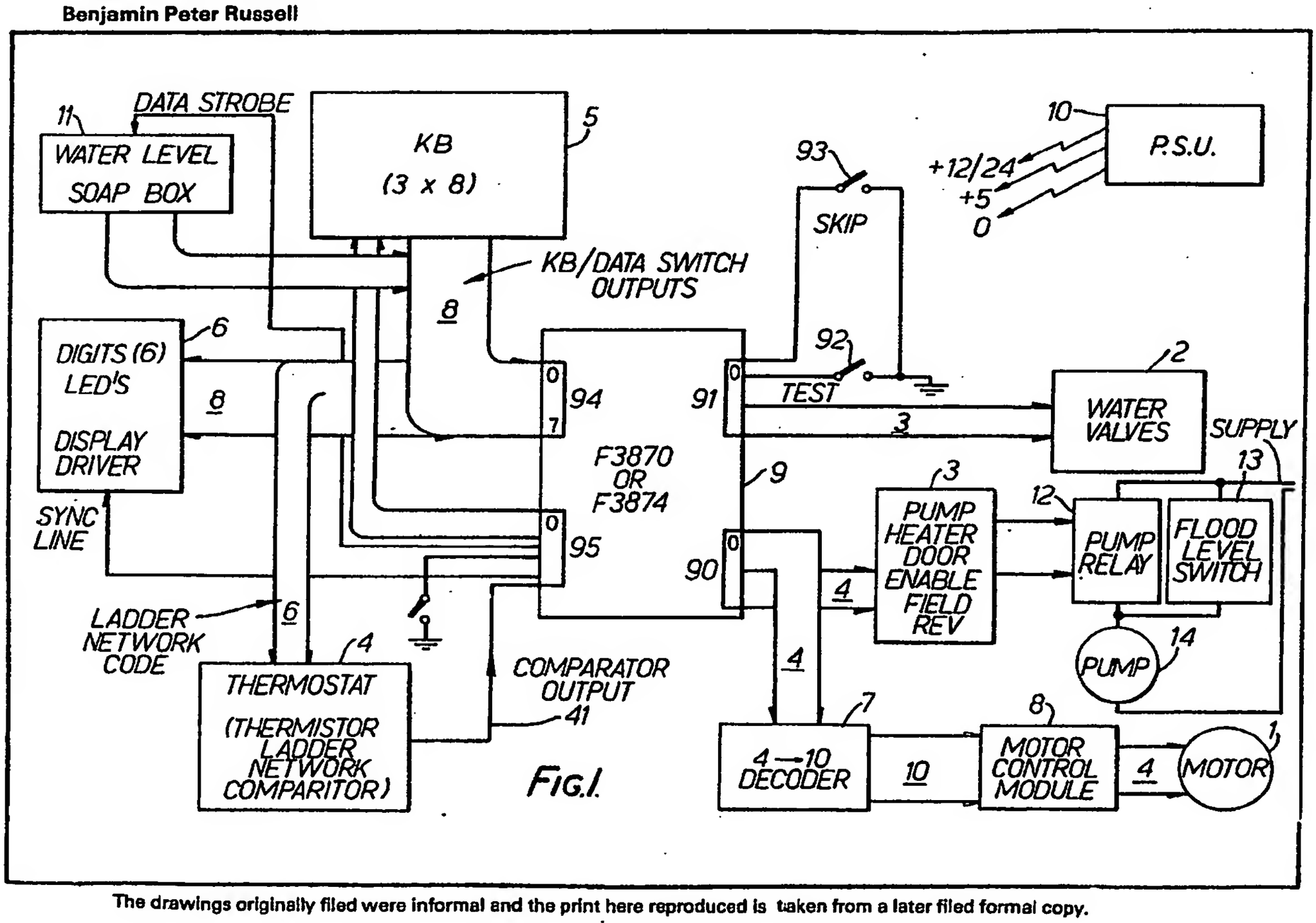


FIG.1.

The drawings originally filed were informal and the print here reproduced is taken from a later filed formal copy.

GB 2 068 589 A

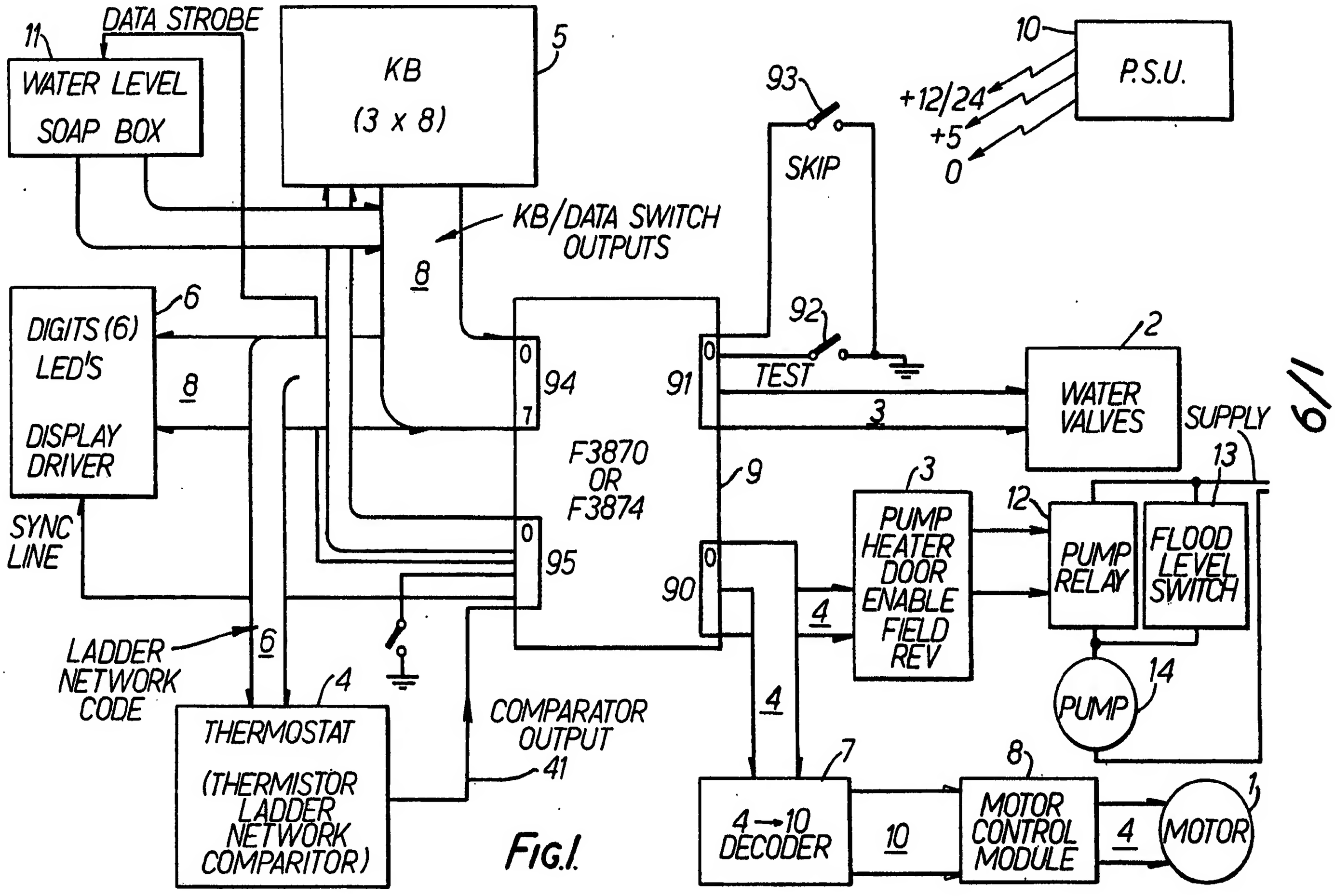


FIG.1.

6/11

2068589

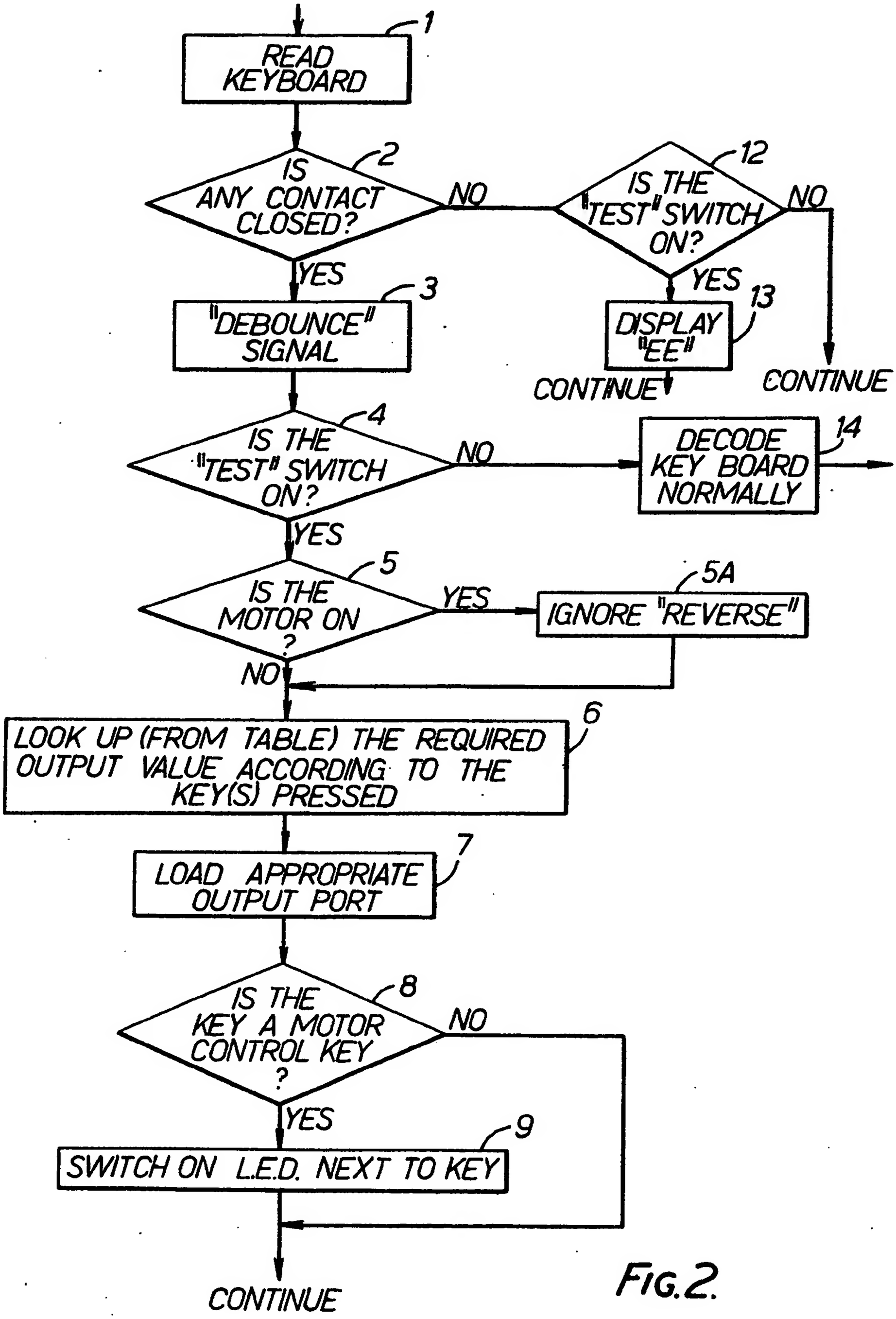

READ KEYBOARD
1
IS ANY CONTACT CLOSED?
2
NO
YES
"DEBOUNCE" SIGNAL
3
IS THE "TEST" SWITCH ON?
4
NO
YES
IS THE MOTOR ON ?
5
YES
NO
IGNORE "REVERSE"
5A
LOOK UP (FROM TABLE) THE REQUIRED OUTPUT VALUE ACCORDING TO THE KEY(S) PRESSED
6
LOAD APPROPRIATE OUTPUT PORT
7
IS THE KEY A MOTOR CONTROL KEY ?
8
NO
YES
SWITCH ON L.E.D. NEXT TO KEY
9
CONTINUE
IS THE "TEST" SWITCH ON?
12
NO
YES
DISPLAY "EE"
13
CONTINUE
DECODE KEY BOARD NORMALLY
14
CONTINUE

FIG.2.

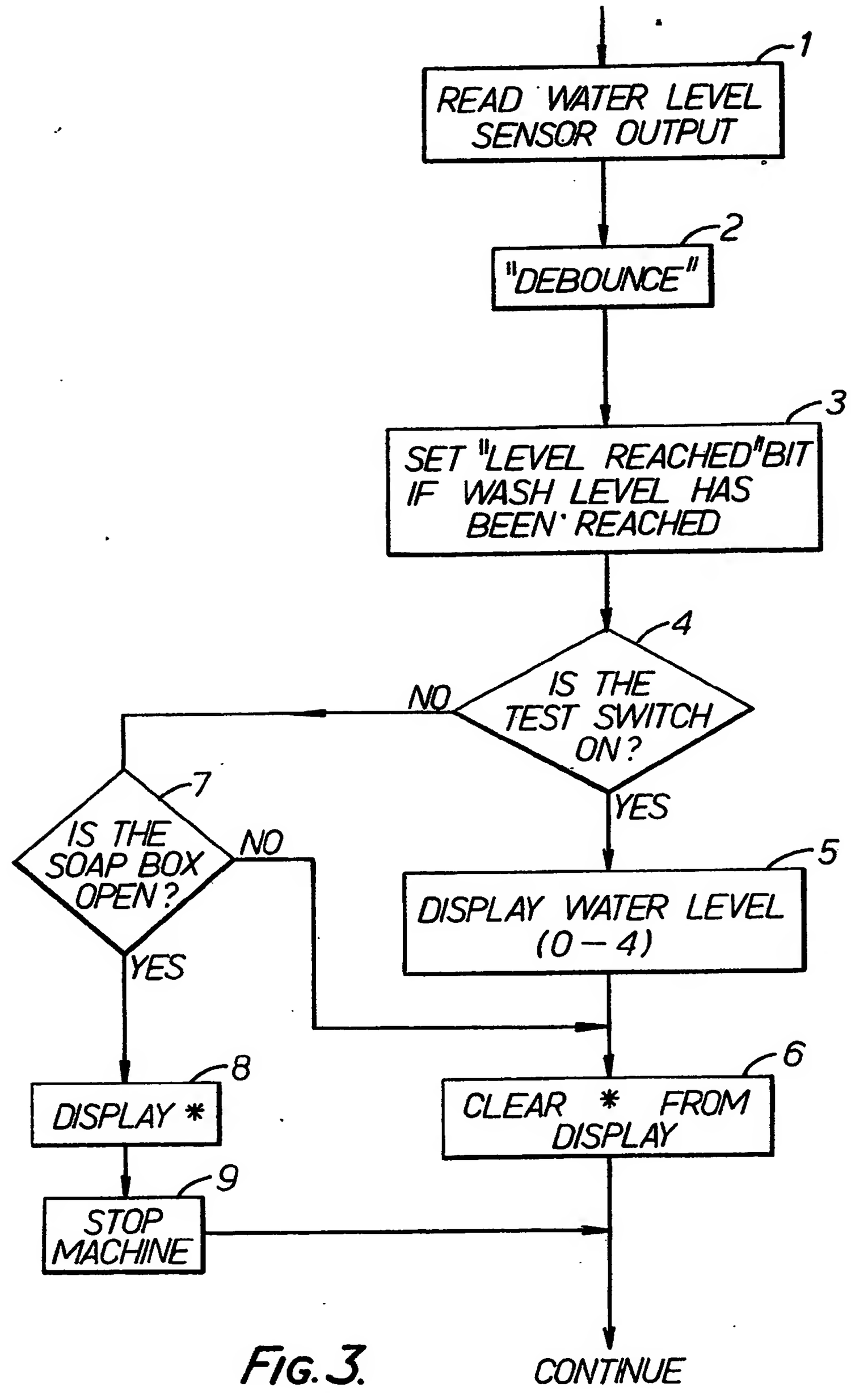

READ WATER LEVEL SENSOR OUTPUT
1
"DEBOUNCE"
2
SET "LEVEL REACHED" BIT IF WASH LEVEL HAS BEEN REACHED
3
IS THE TEST SWITCH ON?
4
NO
YES
IS THE SOAP BOX OPEN?
7
NO
YES
DISPLAY WATER LEVEL (0 – 4)
5
CLEAR * FROM DISPLAY
6
DISPLAY *
8
STOP MACHINE
9
CONTINUE

FIG. 3.

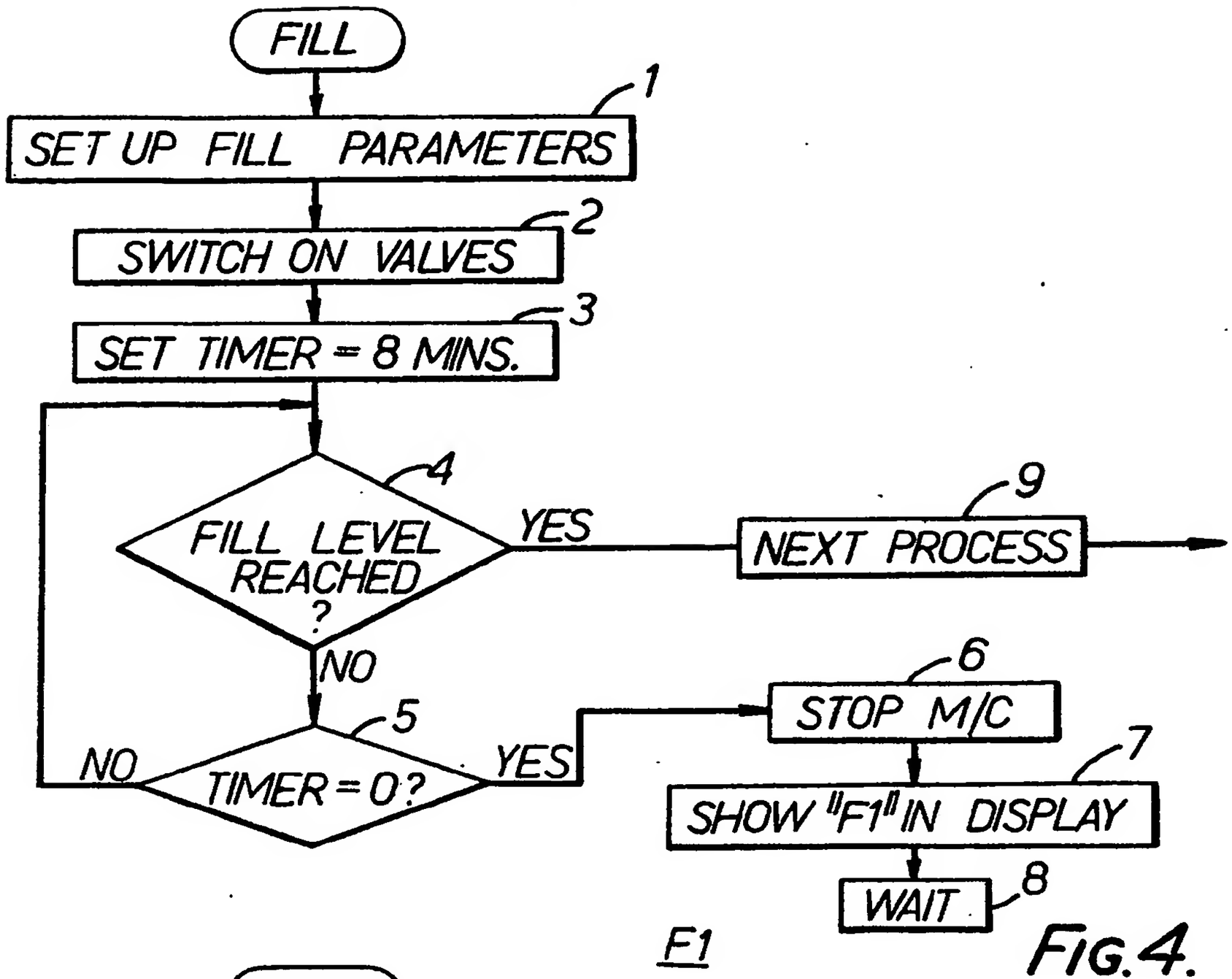

FILL
SET UP FILL PARAMETERS
1
SWITCH ON VALVES
2
SET TIMER = 8 MINS.
3
FILL LEVEL REACHED ?
4
YES
NEXT PROCESS
9
NO
TIMER = 0?
5
NO
YES
STOP M/C
6
SHOW "F1" IN DISPLAY
7
WAIT
8
F1

FIG. 4.

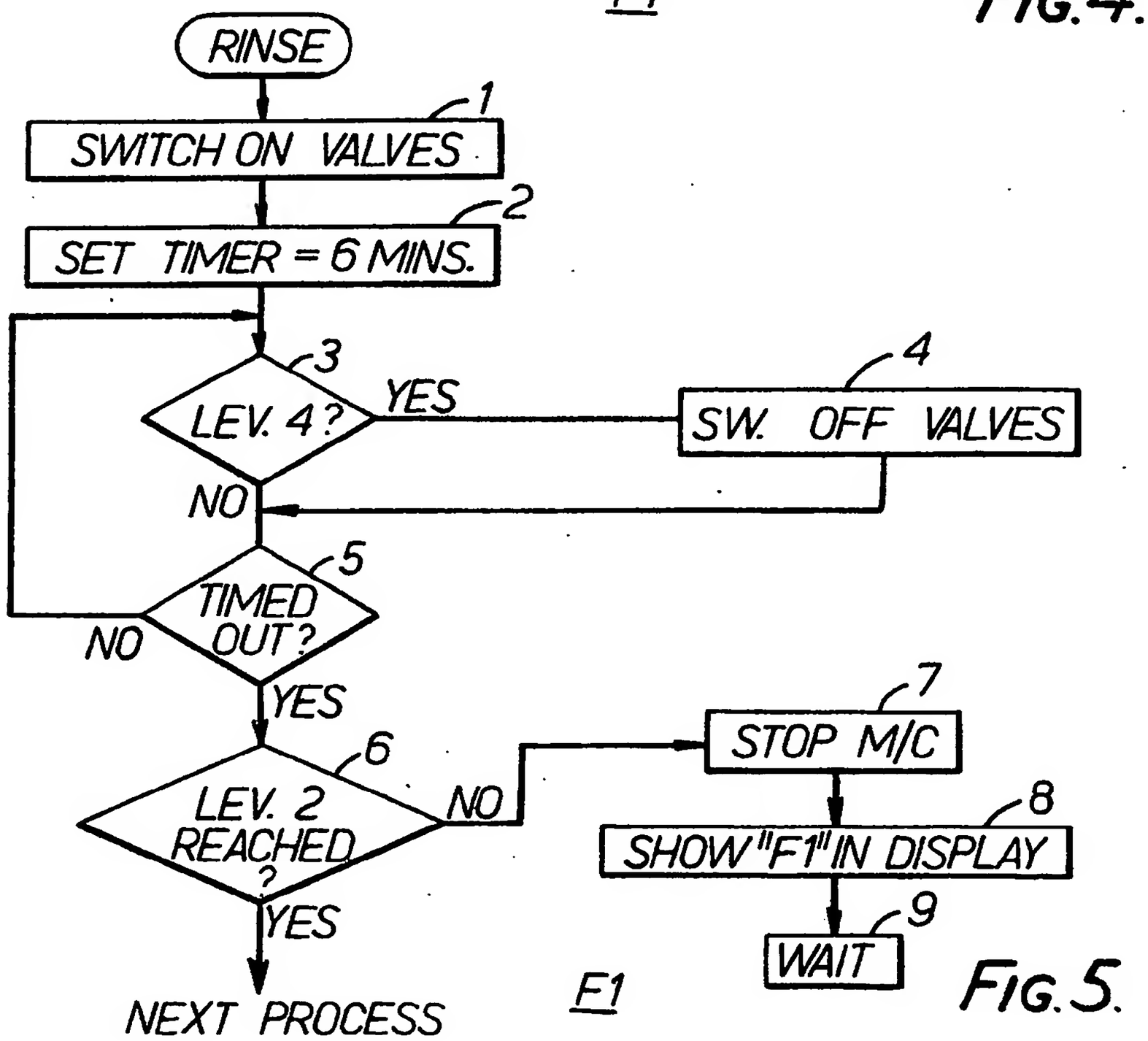
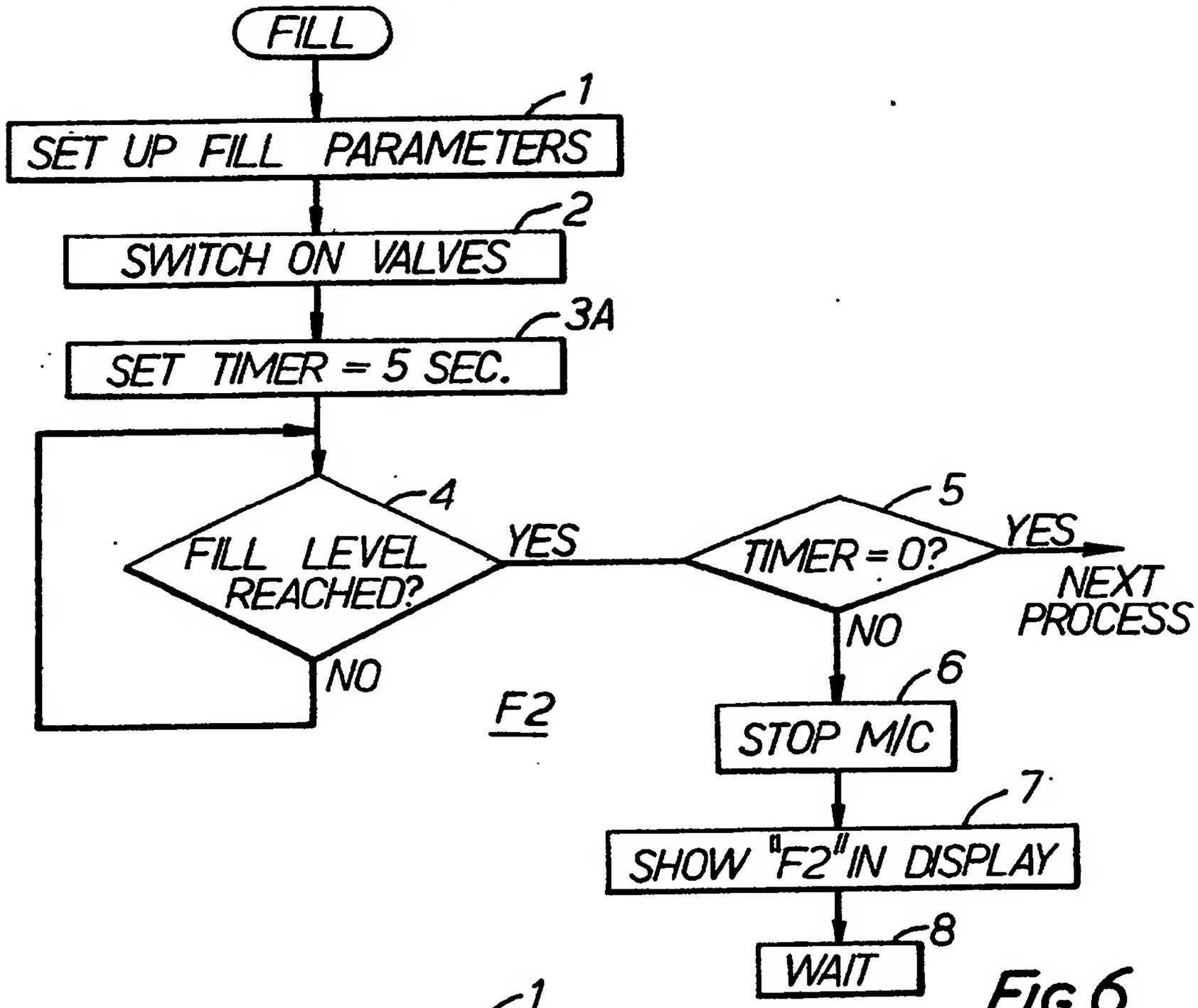
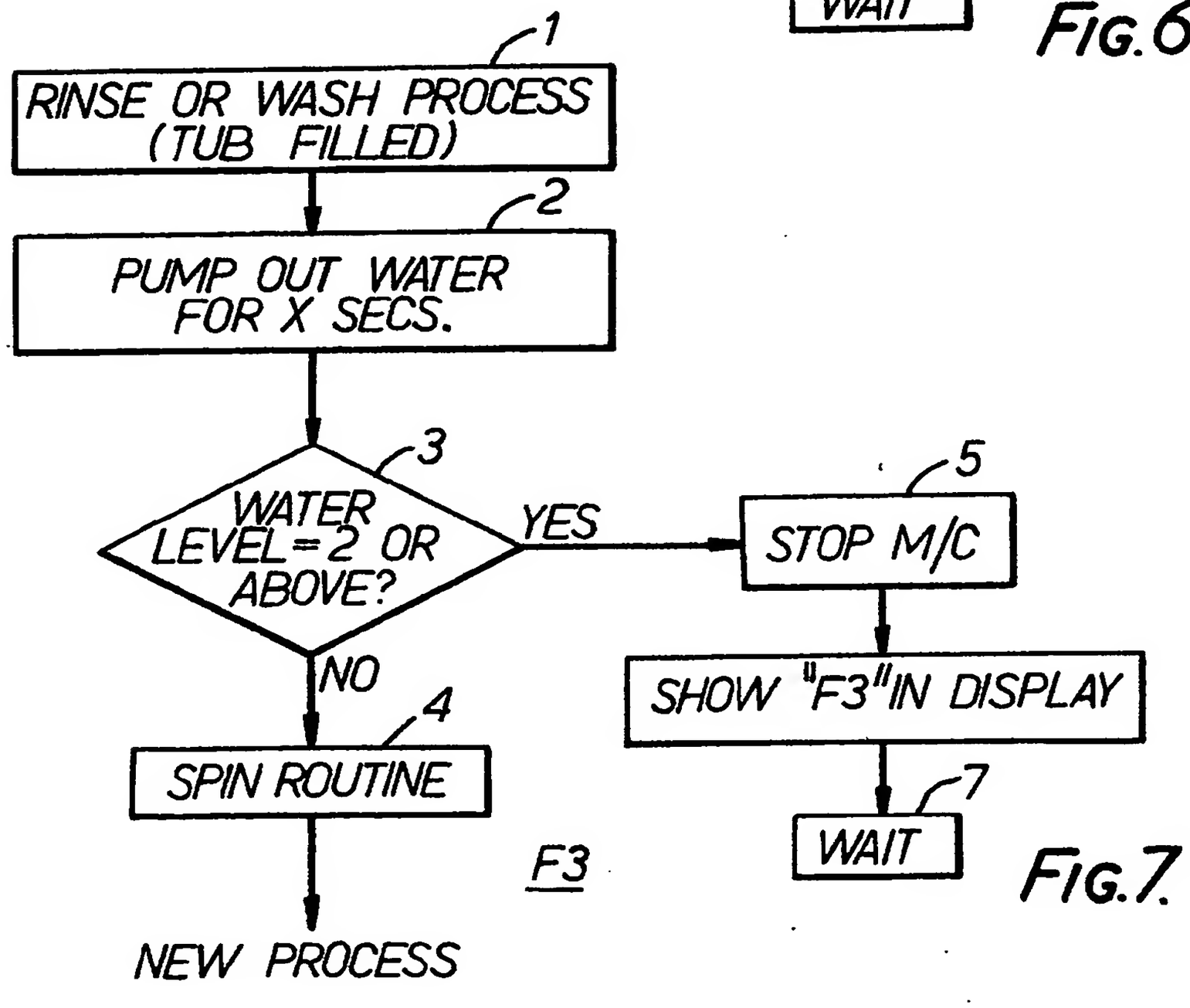

RINSE
SWITCH ON VALVES
1
SET TIMER = 6 MINS.
2
LEV. 4?
3
YES
SW. OFF VALVES
4
NO
TIMED OUT?
5
NO
YES
LEV. 2 REACHED ?
6
NO
STOP M/C
7
SHOW "F1" IN DISPLAY
8
WAIT
9
YES
NEXT PROCESS
F1

FIG. 5.



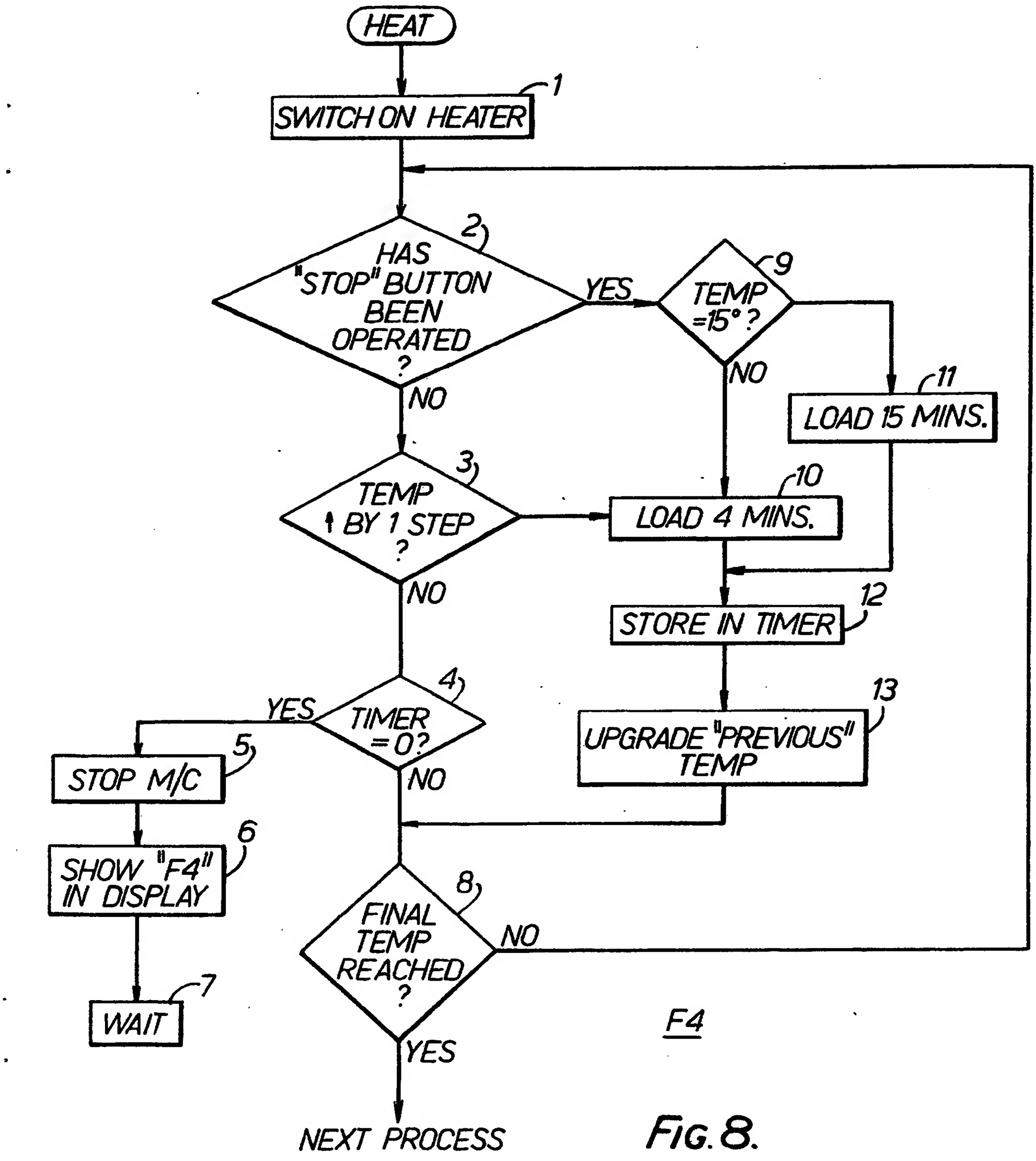
F2

FIG. 6.



F3

FIG. 7.


HEAT
SWITCH ON HEATER
1
2
HAS "STOP" BUTTON BEEN OPERATED ?
YES
NO
3
TEMP ↑ BY 1 STEP ?
NO
4
TIMER = 0?
YES
NO
5
STOP M/C
6
SHOW "F4" IN DISPLAY
7
WAIT
8
FINAL TEMP REACHED ?
NO
YES
NEXT PROCESS
9
TEMP =15° ?
NO
YES
10
LOAD 4 MINS.
11
LOAD 15 MINS.
12
STORE IN TIMER
13
UPGRADE "PREVIOUS" TEMP

F4

FIG. 8.

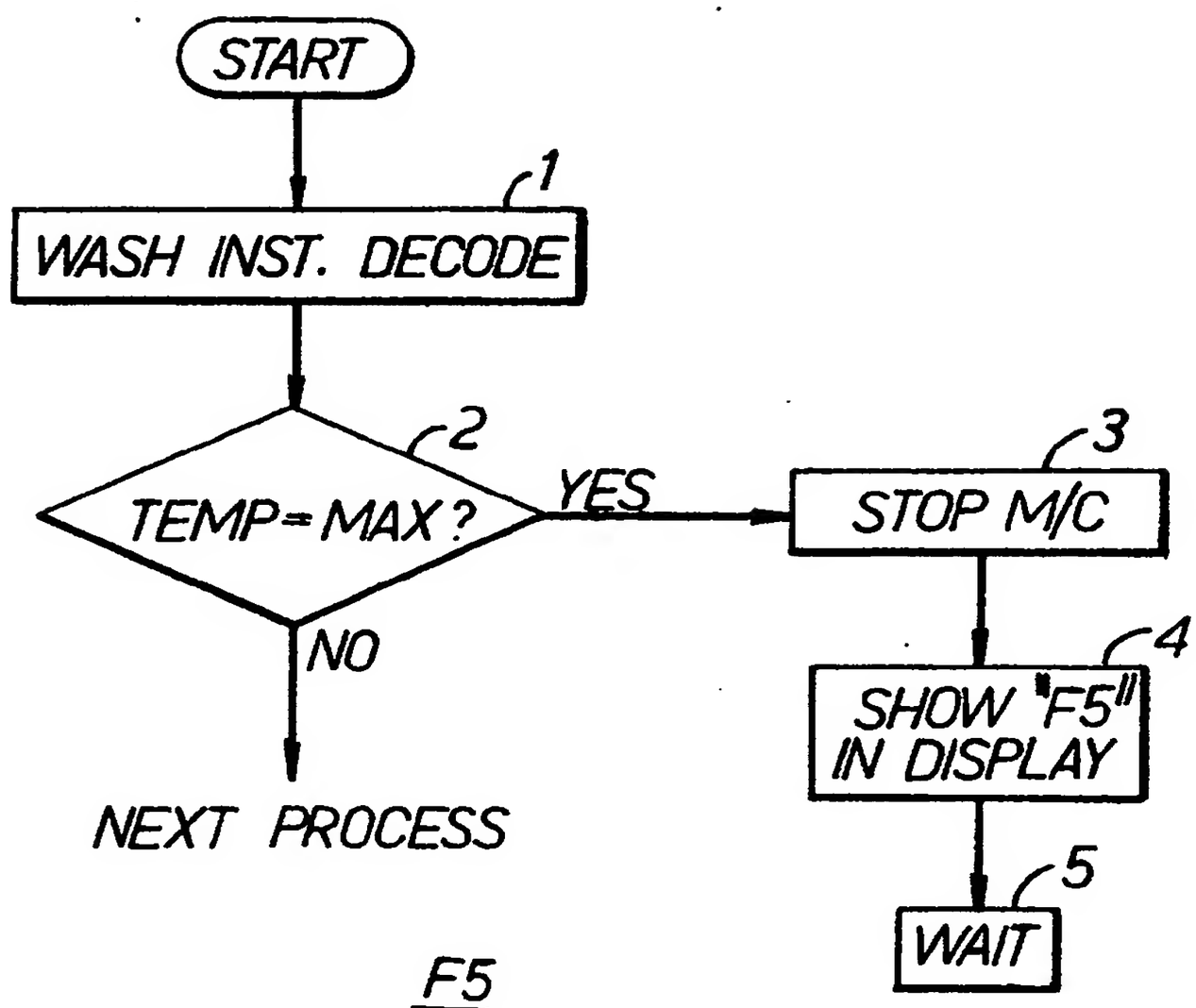

START
1
WASH INST. DECODE
2
TEMP=MAX?
YES
3
STOP M/C
NO
4
SHOW "F5" IN DISPLAY
NEXT PROCESS
5
WAIT
F5

FIG. 9

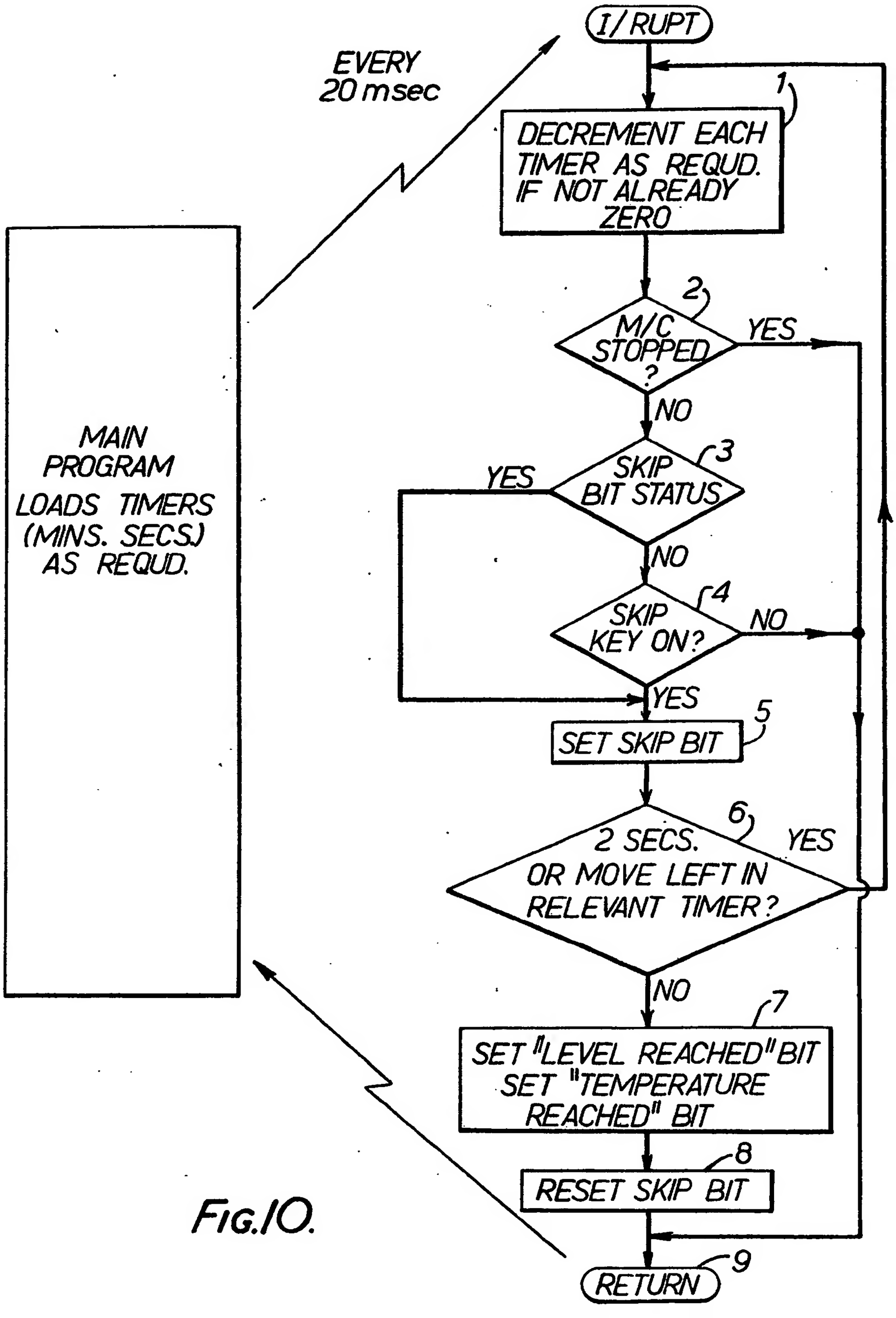

I/RUPT
EVERY 20 msec
MAIN PROGRAM
LOADS TIMERS (MINS. SECS.) AS REQUD.
1
DECREMENT EACH TIMER AS REQUD. IF NOT ALREADY ZERO
2
M/C STOPPED ?
YES
NO
3
SKIP BIT STATUS
YES
NO
4
SKIP KEY ON?
NO
YES
5
SET SKIP BIT
6
2 SECS. OR MOVE LEFT IN RELEVANT TIMER?
YES
NO
7
SET "LEVEL REACHED" BIT
SET "TEMPERATURE REACHED" BIT
8
RESET SKIP BIT
9
RETURN

FIG.10.

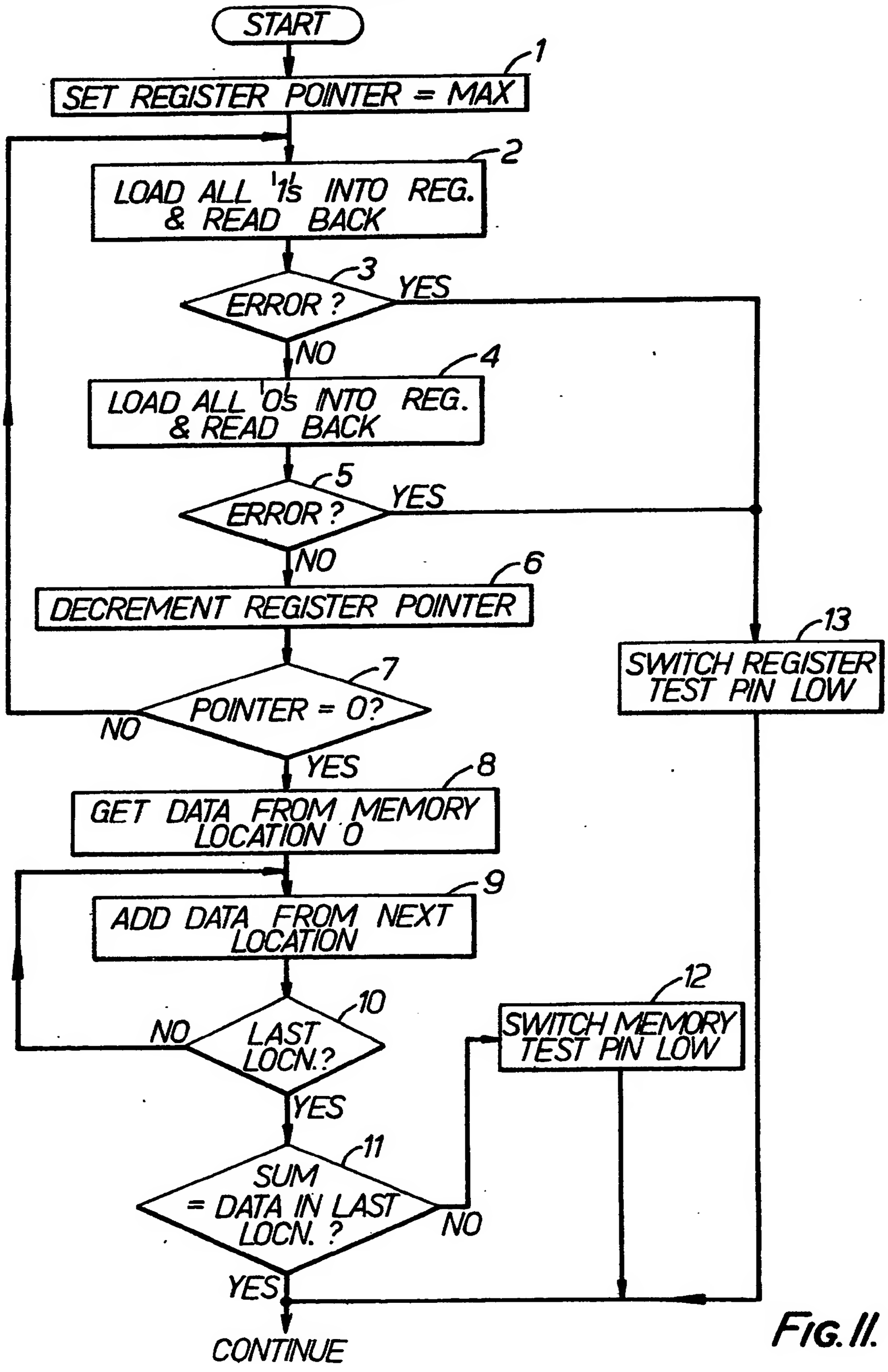

START
SET REGISTER POINTER = MAX
1
LOAD ALL '1's INTO REG. & READ BACK
2
ERROR ?
3
YES
NO
LOAD ALL '0s INTO REG. & READ BACK
4
ERROR ?
5
YES
NO
DECREMENT REGISTER POINTER
6
POINTER = 0?
7
NO
YES
GET DATA FROM MEMORY LOCATION 0
8
ADD DATA FROM NEXT LOCATION
9
LAST LOCN.?
10
NO
YES
SUM = DATA IN LAST LOCN. ?
11
NO
YES
SWITCH MEMORY TEST PIN LOW
12
SWITCH REGISTER TEST PIN LOW
13
CONTINUE

FIG. 11.

SPECIFICATION

Improvements in and Relating to Process Controllers and Programme-controlled Machines

The invention relates to process controllers suitable for controlling mechanical operations, and in particular to controllers in which a repertoire of operations exist as programs in an electrical memory device, and to programme-controlled machines with process controllers.

Machines which employ a process controller for controlling mechanical operations include clothes washing machines in which a selection of wash treatments are provided in order to permit the washing of different fabrics. In conventional washing machines, selection of wash treatment is by means of switches which are marked to indicate wash temperature for the operation or fabric code for which the treatment is suitable, and once the machine is started it runs through a programmed cycle of operations corresponding to the selected treatment. Machines other than washing machines execute a selected programmed sequence appropriate to the function of the machine.

In machines having the facility for executing a selected programmed sequence of operations according to a program held in an electrical memory device, the failure to complete the sequence may be due to failure of the control system or failure of a controlled component, and location and correction of the defect is often a time-consuming process. Where the control system employs solid state electronic components the isolation of a defective component is more difficult, and the difficulty of checking an electronic component may lead to the replacement of components which are perfectly sound before any attempt is made to locate the faulty component.

It is an object of the present invention to alleviate the maintenance problem.

According to the invention, a process controller adapted to control a programme controlled machine, includes:—

(i) data processing means including a central processing unit, addressable data storage means arranged to store data for and data from the central processing unit, and programme storage means arranged to control operation of the central processing unit,

(ii) sensors arranged to provide input data to the data processing means dependent on the state of a controlled machine,

(iii) output means responsive to output data from the data processing means and arranged to control the state of the controlled machine, and,

(iv) manual control input means coupled to the date processing means,

wherein the programme storage means includes test programme storage means, implemented by test selection means, providing machine operation in a test state under the control of the manual control input means.

Preferably, the test programme storage means is so arranged to control operation of the central processing unit as to provide selective energisation of the output means by the manual control input means.

Advantageously, the user control means includes control switches, and the test programme storage means is so arranged to control operation of the central processing unit as to provide a plurality of control signals, selected by combinations of the control switches, to an output means.

Preferably, the output means controllable by the said plurality of signals is a motor controller.

Advantageously, the test programme storage means is so arranged to control operation of the central processing unit as to provide a plurality of control signals, dependent on a sequence of control switches, to an output means.

Preferably, the output means controllable by said plurality of signals is a thermal relay.

Preferably, the test programme storage means is so arranged to control operation of the central processing unit as to override selected machine interlocks.

Preferably, the test programme storage means is so arranged to control operation of the central processing unit as to maintain machine safety interlocks.

Advantageously, the programme storage means includes operational test storage means, attached to process control storage means, so arranged to control operation of the central processing unit as to check periodically the data inputs of the sensors and to compare the respective inputs with required inputs.

Preferably, the operational test storage means is so arranged to control operation of the central processing unit that a defect is indicated when the actual and required states are not comparable.

Advantageously, the process control storage means is so arranged to control operation of the central processing unit as to permit skipping of selected operations.

Preferably, the programme storage means includes additional test programme storage means so arranged to control operation of the central processing unit as to load the addressable data storage means with preset data and to check the data actually stored with reference data.

A clothes washing machine, having a process controller according to the present invention will now be described by way of example only and with reference to the accompanying drawings in which:—

Fig. 1 is an electrical block diagram representation of the washing machine,

Fig. 2 is a flow diagram representation of steps executed by data processing means in the machine in response to a user control input in a test mode,

Fig. 3 is a flow diagram representation of the steps executed by the data processing means in reading its water level sensors and in overriding the soap box interlock,

Fig. 4 is a flow diagram representation of the steps executed by the data processing means in performing its operational test check during a filling operation,

Fig. 5 is a flow diagram representation of the steps executed by the data processing means in performing its operational test check during its rinse operation,

Fig. 6 is a flow diagram representation of the steps executed by the data processing means in performing its operational test check during another filling operation,

Fig. 7 is a flow diagram representation of the steps executed by the data processing means in performing its operational test check during its tub emptying operation.

Fig. 8 is a flow diagram representation of the steps executed by the data processing means in performing its operational test check during its water heating operation,

Fig. 9 is a flow diagram representation of the steps executed by the data processing means in performing its operational test check on its temperature sensor,

Fig. 10 is a flow diagram representation of the steps executed by the data processing means in performing its skip operation, and

Fig. 11 is a flow diagram representation of the steps executed by the data processing means in performing its additional tests on its addressable data store.

Fig. 1 shows in block diagram form, the components of a clothes washing machine considered as an electrical system. The washing machine system includes a motor 1, water valves 2, and pump, heater, door, and motor-reversing controls 3. In addition, there is a thermostatic control device 4, an "instruction" keyboard 5, a digital display with display driver 6, a motor control module 8 and its associated data converter 7. The washing machine system also includes a microprocessor 9 arranged to accept instructions from the keyboard 5 and to supply the appropriate signals to the remainder of the system to execute the keyboard instructions. A power supply 10 is also present to provide electrical power supplies to those components which require d.c. voltages and other supplies not available directly from the mains supply. The washing machine represented by the block diagram is arranged to execute generally known washing operations.

The microprocessor 9 is an electrical sub-system which includes a fixed digital program store, an alterable digital data store, four bidirectional input-output ports, and an arithmetic logic unit. The bidirectional input-output ports are identified as 90, 91, 94, and 95, and provide the means by which the microprocessor 9 communicates with the remainder of the washing machine system. The microprocessor 9 controls the system by providing on/off signals at locations of its input-output ports to switch on and switch off the other components as necessary. Operation of the microprocessor is controlled by the contents of its program store, and execution of its program is effected by use of its arithmetic logic unit and alterable data store in known manner.

A plurality of sensors shown collectively as 11 in Fig. 1 are included in the washing machine system. Pressure operated switches are included for water level sensing. In the case of the soap box, a microswitch is arranged to be operated by insertion of the soap box.

A door-operated switch is included in series with the machine power supply line so as to remove power from the machine when the door is open. A door-lock relay is used to prevent door opening in certain circumstances during machine operation.

A flood level switch 13 is connected in parallel with the pump relay 12 so as to energise the pump at any time that the flood level switch 13 closes.

The microprocessor 9 is arranged not only to provide drive signals which control operation of the water valves, pump, heater, motor, etc., but also to monitor the states of the sensors, and thereby to assess whether or not the drive signals which should lead to alteration in the signals from sensors or a sensor are having the desired effect. In the case of drive signals being applied to open the water inlet valves, the water level sensor should detect an increase in water level within a predetermined time if the system is operating correctly. The microprocessor includes program data which indicates what reading should be obtained at the end of a specified time for the water level, and at the end of that time the actual and programmed results are compared. If the desired result is attained, the microprocessor 9 proceeds to the next phase of the specified washing operation, but if the result is not attained it halts the operation and indicates a malfunction by displaying F1. The indication F1 could mean either that no water is being admitted to the tub of the washing machine, or that the water level sensor has given an indication of an open circuit (or both).

If a water level sensor fails short circuit, the water level reading received by the microprocessor will represent a prematurely high water level, and the persistance of the reading will be reported by the micro-processor by the display of F2.

When the machine enters the spin phase, water is to be drained from the tub before any spinning takes place. The microprocessor energises the pump and monitors the water level in the tub. The water level should of course fall progressively to zero, and the absence of a zero water level indication from

the water level sensor at the end of a specified time after pump energisation is reported by the microprocessor as a fault condition displayed as F3.

The washing machine is also required to provide a selected wash water temperature for each washing operation. The selected or required temperature is included in the program data provided in the microprocessor, and the thermostatic control device 4 is used in association with the heater included in the pump/heater/etc. control 3 to change the wash water temperature as necessary. The thermostat 3 includes a negative temperature coefficient (NTC) thermistor (not shown) which is arranged to sense the wash water temperature and a comparator (also not shown) which compares a voltage level derived from a circuit including the thermistor with a reference voltage level provided by the microprocessor 9. The output signal from the comparator appears on a connection 41 to indicate to the microprocessor 9 the relative magnitudes of the wash water temperature and the required value. When the heater has been energised by the microprocessor 9, a persistent indication from the comparator that wash water temperature is low or not increasing is reported as a fault displayed as F4. The fault may be an open circuit heater or an open circuit thermistor (or both). The thermistor may become a short-circuit, and yield a continuing indication that the wash water temperature exceeds the desired temperature. A short-circuit fault is reported by the display of F5.

It is of course necessary that the soap box should be inserted and the door closed before and during a washing operation. With the door open, the mains supply to the machine is broken and operation cannot commence.

Once operation commences an electromechanical lock on the door is activated. In the same way, partial or complete removal of the soap box will both prevent operation in the first place and stop the machine during operation.

In the washing machine represented by the electrical system shown in Fig. 1, the general checks for faults during operation, as described above, are supplemented by means of more specific checks. In the arrangement illustrated in Fig. 1, the keyboard 5 is a cross-point switching matrix which controls the microprocessor 9 by returning to the microprocessor port 94, pulses generated at the microprocessor port 95, when a key is pressed. The pulses generated at the port 95 and received at the port 94 are in the nature of program memory addresses which direct the microprocessor to specific locations within the program memory. When the instructions stored in the program memory are executed the system carries out the operations corresponding to the actuated key.

The program memory includes special test program locations not accessible by the keyboard in normal operation, but which become accessible when a test switch 92 is closed to place a logic "1" level at one location of the port 91. The condition of the switch 92 is checked periodically by the microprocessor 9 during its normal operation mode, and when it finds that the switch 92 is closed it restricts its operation to the part of its program related to the special test program.

Another switch 93 is also provided, and when this is closed the microprocessor is caused to skip over parts of the wash program as required.

When the keyboard 5 becomes dedicated to the control of the test mode the individual keys are allocated as follows to provide keyboard control of the following components:—

1. Programme Button No. 1—Hot water Solenoid Valve
2. Programme Button No. 2—Cold water Solenoid Valve
3. Programme Button No. 4—Fabric Conditioner Solenoid Valve
4. Programme Button No. 5—Pump
5. Programme Button No. 7—Heater Relay
6. Programme Button No. 8—Door/Motor Thermal Relay
7. Option Button Prewash
   Option Button Economy
   Option Button Hold
   Option Button Fast Programme
   } Motor speeds.
8. Option Button Half Load — Motor Reversing Relay

In the use of the above buttons to performing checking of components of the machine by operational testing, a first operation of a button energises the associated component and a second operation de-energises the component.

The STOP button may be used to switch off all selections with the exceptions of the motor thermal relay and the motor reversing relay.

Although Programme Button No. 7 energises the heater relay, the heater is not energised unless there is water in the tub to a specific level. Heater operation may be checked by energising the heater relay with the appropriate water level in the tub and observing the temperature reading provided by the temperature display.

Motor speeds are selected on a "module bit" basis by operation of the Prewash, Economy, Hold and Fast Programme Buttons as follows:— (A "1" indicates Button operation)

Motor Speed (RPM)	Prewash	Economy	Hold	Fast Programme
0	0	0	0	0
40	0	0	0	1
50	0	0	1	0
84	0	0	1	1
350	0	1	0	0
450	0	1	0	1
600	0	1	1	0
750	0	1	1	1
850	1	0	0	0
1000	1	0	0	1

In the use of the Prewash, Economy, Hold and Fast Programme Buttons for operation of the motor at a plurality of speeds, the central processing unit 9 (Fig. 1) checks keyboard data at its input port 94 which could be any one of the "module bit" combinations and selects the appropriate output signal to output port 90. For example, should a speed of 600 RPM be required, the system will detect that the Economy Button has been operated and will follow a decision path corresponding to a YES decision on the check for operation of this Button and will subsequently do the same for the Hold Button. This combination of YES decisions corresponds uniquely to a logic path and an instruction to load a corresponding binary pattern on to output port 90. In a similar manner, each of the other Button combinations has a unique decision path and output value instruction to give the appropriate speed.

Light-emitting diode indicators are re-allocated to indicate the condition of each of the Buttons in order to provide the operator with a visual indication of the Button operation combination.

The door thermal relay is also provided with a plurality of control signals by way of output port 90. Operation of Programme Button 8 energises the thermal relay fully by loading on to output port 90 the normal output value for thermal relay energisation. The FAST SPIN and SLOW SPIN light-emitting diode indicators are energised to indicate this condition. Subsequent operation of the STOP Button results in a modulated output value on output port 90, with a 1/3 duty cycle. Subsequent operation of Programme Button 8 switches off the thermal relay and allows a check to be made on the time delay before door release. In this instance, the sequential operation of two Buttons is used to provide a plurality of thermal relay conditions.

In the test mode, a display EE is maintained. Access to wash routine programs is prevented in the test mode.

In the execution of the test program, the hot water, cold water, and fabric conditioner valves are opened in turn to introduce water into the machine tub, and after admitting the water, it is removed by energising the pump. When water is being admitted to the tub, water level indicator provides an indication by the display of 0, 1, 2, 3, 4, where 4 represents full 0 represents empty, and 1, 2, and 3 represent intermediate levels. The door interlock system can be checked by switching the motor on with the door lock thermal relay not energised to check that the motor does not run, and subsequently energising the relay to observe that the motor then runs, and that the door cannot be opened.

In the test mode, with the motor energised, motors speeds may be selected according to the "module bit" pattern given above, and the speeds can be checked by means of a tachometer. Extra safety interlocks exist in the test mode. For example, an instruction for motor reversal is ignored when the motor is running. Additionally, it may be arranged that the motor will not run with certain water levels in the tub.

Fig. 2 is now referred to for a more detailed description of the sequence of operations involved in providing for checking of components of the machine by means of the existing control devices.

The keyboard 5 (Fig. 1) is read (instruction point 1) in the course of operation for any contact closure (decision point 2). In the event of a key closure the signal is "debounced" in known manner (decision point 3) and then test switch 92 (Fig. 1) is examined (decision point 4). If the test switch 92 is open (decision No) the machine state appropriate to the key operated is set up (instruction point 14). If the test switch 92 is closed (decision YES) the machine moves into a sequence of operations accessible only with the test switch 92 closed, checking first whether or not the motor Fig. 1 is running (decision point 5). Should the motor 1 be running (decision YES) any instruction leading to motor reversal is ignored (instruction point 5A). The next operation (instruction point 6) results in the selection, from a memory table, of an output value dictated by the key which has been operated, and the data placed on the appropriate output port instruction point 7). In the event that the key which has been operated is a motor control key (decision YES at decision point 8), a light-emitting diode (LED) or any other indicator device identifying the activated key is illuminated (instruction point 9, and the machine proceeds.

It will be noted that Fig. 2 illustrates that, with the test switch 92 open, machine operation proceeds to instruction point 14 at which the keyboard 5 provides normal operation, and with the test switch 92 closed machine operation proceeds to instruction point 6 at which the keyboard 5 provides

operation determined by a memory table. The memory table is such as to provide selective energisation of machine components from the keyboard 5.

Fig. 3 is now referred to. In the sequence of operations shown in Fig. 3, the water level sensor output is read (instruction point 1), "debounced" (instruction point 2) and then the actual value is checked against a value set in a memory table (instruction point 4). If the check indicates that the actual value lies within limits set by the memory table then the sequence continues to a check on the state of the test switch 92 (Fig. 1) (decision point 4). If the test switch 92 is open (decision NO) a check is made on the soap box (decision point 7) and if it is open (decision YES) an indication is given (instruction point 8), the machine is stopped (instruction point 9), the control system continues and will return subsequently to re-check the soap box. Should the soap box be inserted at a subsequent check the alternative exit (decision NO) following the check on the soap box switch (decision point 7) will be followed and the display changed correspondingly (instruction point 6) to indicate that the soap box is fully inserted.

In Fig. 3 an alternative exit (decision YES) following the check on the test switch 92 (Fig. 1) (decision point 4) leads to the display of the water level sensor output (instruction point 6) when the machine is in the test mode, since "decision YES" at decision point 4 represents the test mode.

Fig. 4 is an illustration of the operations performed by the system in monitoring the water level sensors.

As shown in Fig. 4, at the start of the "wash" state of a machine cycle, reference water level values for the parameters corresponding to the "wash" state are set up in a memory (instruction point 1) and the inlet valves are energised (instruction point 2). A time, by which the parameters should be achieved, is set (instruction point 3) and the actual level checked (decision point 4) by reading the level sensors. If the required level has been reached (decision YES) the control sequence continues (instruction point 9), and if not (decision NO) the timer is checked (decision point 5). If the timer is still running (decision NO) the sequence returns to check the level (decision point 4) but if the set time has elapsed (decision YES) the machine is stopped (instruction point 6), "F1" is displayed (instruction point 7) and the sequence is discontinued (instruction point 8).

It will be noted that, according to Fig. 4, the control system compares at various times, the signals from the level sensors with a set value and checks also the state of a timer which has been loaded previously.

Fig. 5 is now referred to as an illustration of control system operation on entry to "rinse" state. The water level required is set as being level 4 (not shown), the inlet valves opened (instruction point 1) and the timer set (instruction point 2). The system then circulates within a decision loop (decision points 3, and 5) and leaves the loop when the timer has run out (decision YES at decision point 5) if level 4 has been reached before the timer has run out the inlet valves will have been shut (instruction point 4). The level sensors are checked when the timer has run out to determine whether or not level 2 has been reached (decision point 6). If level 2 has been reached (decision YES) the sequence is continued. If level 2 has not been reached the machine is stopped and a fault condition indicated as before (decision points 7, 8, 9).

Fig. 6 is now referred to in order to illustrate the sequence leading to the display of F2 in a fault condition where the water level indicator is prematurely high. The initial operations (instruction points 1 and 2) are the same as those in Fig. 3. The timer setting (instruction point 3A) differs from that of Fig. 3 but the essential difference lies in the fact that a fault condition exists when the fill level is reached before the timer runs out (decision YES at decision point 4 followed by decision NO at decision point 5).

Fig. 7 illustrates in detail the sequences leading to a display of fault "F3". The necessary water level and time parameters are set up initially (instruction points 1, 2) to a given level (instruction point 1). Water is then pumped out prior to spin (instruction point 2) and a water level check made just prior to entering spin (decision point 3). If water is above level 2 (decision YES) fault "F3" is reported (instruction points 5 to 7). Otherwise (decision NO) the machine spins (instruction point 4) and the sequence continues.

Fig. 8 illustrates in sequence of operations leading to fault indication F4 during a heating cycle. Initially the heater is energised, (instruction point 1) and a check is made to determine whether or not the STOP control has been operated (decision point 2). If the STOP control has not been operated (decision NO), a check is made on whether or not the temperature has risen (decision point 3) by 1° or 2° (depending on the wash programme selected). If the temperature has increased (decision YES), a 4-minute delay is introduced (instruction points 10 and 12), and the cycle repeated (instruction point 13, decision point 8—decision NO), until the temperature does not rise (decision NO at decision point 3) and then the timer condition is checked (decision point 4). If the time left is zero (decision YES), the machine has not attained the required temperature, fault F4 is reported (instruction point 5 and 6), and the machine is stopped (instruction point 7). Otherwise the machine continues to the next state in the cycle.

Should the STOP control have been operated (decision YES at decision point 2) the machine remains stopped and the control system circulates in the loop including points 9 to 13 until the STOP instruction is cancelled.

Fig. 9 illustrates in detail the sequences of operation leading to a fault F5 indication. At start up of a washing instruction (instruction point 1) the thermistor signal is checked against its maximum value (decision point 2) and fault F5 reported if it is at its maximum value (decision YES).

Fig. 10 is now referred to for details of the "skip" action of the system. Throughout operation, timers relevant to each state are decremented (instruction point 1), the machine checked for operation (decision point 2) and the skip status checked (decision point 3). When a "skip" condition has been set up previously (decision YES) or skip key operation is recognised (decision NO, decision YES at decision point 4) a check is made of the time left in the current process (decision point 6). If this time equals or exceeds 2 seconds, time is decremented rapidly by looping back until the time left equals 2 seconds. The operation then leaves the loop (decision NO at decision point 6). Conditions are then fulfilled artificially to ensure that the particular state is terminated (instruction point 7). The system then removes the stored "skip" instruction (instruction point 8) and continues into the next machine state (instruction point 9).

Fig. 11 illustrates a sequence of operations the central processing unit performs on its memory stores in order to detect memory defects before the start of machine operation. The system loads its register pointer (instruction point 1) which is decremented sequentially to step through the control sequence. The selected register memory in the system is then loaded with binary 1's and the stored data read back (instruction point 2). An error during read-back (decision point 3) leads to an error output indication (instruction point 13). A further test is conducted with binary 0's loaded into the register memory (instruction point 4) and checks made for errors as before (decision point 5). These checks are repeated until the register pointer is zero (instruction point 6, decision point 7) when all register will have been checked.

A further check is then conducted by adding the stored data from all but the last memory locations (instruction points 8, 9, decision point 10) and comparing the result with a correct value sum set in the last location (decision point 11). Failure leads to an output indication (instruction point 12). The system continues into machine operation when self-test checks are passed.

Although the invention has been described with reference to a clothes washing machine it is applicable to other machines having data processors controlling their operations.

In addition it will be appreciated that the control system may be arranged as a detachable component, for example a control panel, of a machine.

Claims

1. A process controller adapted to control a programme-controlled machine and including:—

(i) data processing means including a central processing unit, addressable data storage means arranged to store data for and data from the control processing unit, and programme storage means arranged to control operation of the central processing unit,

(ii) sensors arranged to provide input data to the data processing means dependent on the state of a controlled machine,

(iii) output means responsive to output data from the data processing means and arranged to control the state of the controlled machine, and

(iv) manual control input means coupled to the data processing means,

wherein the programme storage means includes test programme storage means, implemented by test selection means, providing machine operation in a test state under the control of the manual control input means.

2. A process controller as claimed in claim 1, wherein the test programme storage means is so arranged to control operation of the central processing unit as to provide selective energisation of the output means by the manual control input means.

3 A process controller, as claimed in claim 2, wherein the user control means includes control switches and the test programme storage means is so arranged to control operation of the central processing unit as to provide a plurality of control signals, selected by combinations of the control switches, to an output means.

4. A process controller as claimed in claim 3, wherein the output means is a motor controller.

5. A process controller claimed in claim 3, wherein the test programme storage means is so arranged to control operation of the central processing unit as to provide a plurality of control signals, dependent on a sequence of control switches, to an output means.

6. A process controller as claimed in claim 5, wherein the output means is a thermal relay.

7. A process controller as claimed in any one of the preceding claims, wherein the test programme storage means is so arranged to control operation of the central processing unit as to override selected machine interlocks.

8. A process controller as claimed in any one of the preceding claims, wherein the test programme storage means is so arranged to control operation of the central processing unit as to maintain machine safety interlocks.

9. A process controller as claimed in any one of the preceding claims, wherein the programme storage means includes operational test storage means, attached to process control storage means so

arranged to control operation of the central processing unit as to check periodically the data inputs of the sensors and to compare the respective inputs with required inputs.

10. A process controller as claimed in claim 9, wherein the operational test storage means is so arranged to control operation of the central processing unit that a defect is indicated when the actual and required states are not comparable.

11. A process controller as claimed in any one of claims 9 to 10, wherein the process control storage means is so arranged to control operation of the central processing unit as to permit skipping of selected operations.

12. A process controller as claimed in any of the preceding claims, wherein the programme storage means includes additional test programme storage means so arranged to control operation of the central processing unit as to load the addressable data storage means with preset data and to check the data actually stored with reference data.

13. A control panel including a process controller as claimed in any one of claims 1 to 12.

14. A clothes washing machine including a process controller as claimed in any one of claims 7 to 12.

15. A clothes washing machine substantially as herein described with reference to and as illustrated by the accompanying drawings.

16. A programme-controlled machine including a process controller as claimed in any one of claims 1 to 12.

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Spa, 1981. Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.